amount of light all over the plate. The total brightness of the corona will thus depend on the area of sky included. Assuming this to be a circular area 5° in diameter, the total brightness of the 1898 corona would be about 2·4 times that of full moon, while the 1893 corona was only about 1·1 times brighter than the full moon.

THE SPECTROSCOPIC BINARY "MIZAR."—During March and April of the present year a series of excellent photographs of the spectrum of this star, ζ Ursæ Majoris, were obtained with Spectrograph IV. and the 33 cm. refractor at the Potsdam Observatory. Dr. H. C. Vogel has measured these, and gives the result of the reductions in the *Astrophysical Journal* (vol. xiii. pp. 324–328). On some of the plates as many as sixty-five lines are recognisable, including several of the strongest iron lines and lines of silicon and magnesium. When the period of maximum separation occurs, however, many of these become faint and the measures are more difficult.

On several of the plates the separated magnesium lines at λ 4481 appeared of unequal width, but no change in their behaviour was discernible after a coincidence.

The values of the relative motion are given for twenty-five plates obtained during the period 1901 March 24–May 1, ranging from 158 to 15 kilometres per second.

The motion of the whole system is given as 16 km. per second. A diagram is given showing the velocity curve most nearly representing the final reduced measures, and the period thus deduced is 20·6 days—considerably less than the period of 104 days deduced by Pickering about 1890.

The following provisional elements have been computed from the curve by Lehman-Filhes' method on the assumed values of

Period = 20·6 days.
Maximum relative velocity of A = 128 km.
" " " B = 156 "
T_0 = 1901 March 28·60 (Rel. motion in line of sight = 0).
T = 1901 March 28·88.
$\omega = 101°{\cdot}3$.
$e = 0{\cdot}502$.
$\log \mu = 9{\cdot}4843$.
$\mu = 17°{\cdot}476$.
$a \sin i$ = 35 million kilometres.

$$m + m_1 = \frac{4\odot}{\sin^3 i.}$$

NOVA PERSEI.—In the *Astrophysical Journal* (vol. xiii. pp. 336–7) Messrs. G. C. Comstock and J. Stebbins give a very exhaustive series of comparisons of the estimated brightness of Nova Persei from February 24 to May 12. The observations were made by the "grade" method of Argelander, the estimated error being 0·1 magnitude for a single comparison. The rapid variation of the star is well shown by the many cases where several observations were obtained during the same evening. The minimum magnitude recorded is 5·7. Most of the estimates were made with the help of an opera-glass, the comparison stars being those given on Hagen's special chart of the region.

THE FUTURE OF ELECTRIC TRACTION.[1]

IT is not so long since the Englishman, and perhaps more particularly the Londoner, first tasted the sweets of electric traction, but he has already found it so satisfactory, whether as a profitable investment or as a method of travelling at once comfortable, convenient and healthy, that he is clamouring for its rapid extension and development. It is beginning to be realised, too, that electricity as a motive power is not destined to be confined to metropolitan railways and suburban tramways. The electrification of our larger railways is now being discussed as a practical problem by the more far-sighted of our engineers, who have recognised that many of the railway systems characteristic of this country are peculiarly suited for electrical running. Mr. Langdon, now president of the Institution of Electrical Engineers, devoted a paper read last November before that society to the subject; and Major P. Cardew, in his recently delivered Cantor Lectures, again gave prominence to the question.

It is interesting to consider what are the conditions of working which would make a railway one in which the adoption of electric traction is likely to prove profitable, for unless the alteration results in the increased economy of the system it is clear that it is not likely to be made. "Electric traction," says Major Cardew, "tends towards the ideal of the continuously moving platform," and one may say that the more nearly a railway tends towards the same ideal the more likely is the adoption of electricity as its motive power. In those most closely approaching this limit, namely, the metropolitan railways, all other systems at present known have long been seen (by all except perhaps the directors of the London underground and district railways) to be doomed. The reason lies in the essential difference between steam and electric driving, namely, that in the one case the train must carry its own power generator whilst in the other the power is generated in bulk for a number of trains. Since the generation of power in bulk is much cheaper than in detail, the tendency with steam locomotives is to make each detail as large as possible, and therefore to run heavy trains at long intervals. With electric working, on the other hand, it is desirable to make the load on the generating station as constant as possible, which can only be done when the number of trains is large and each only takes a small fraction of the total load; for in such a case the stopping and starting of individual trains will only have a small percentage effect on the output of power. It will readily be seen, therefore, that for long-distance traffic the steam locomotive is likely for some time to come to hold its own, for here the number of passengers is not so great as to be able to support a very frequent service of light trains, and, moreover, the time taken over the journey, being nearly the whole of the day or night, practically fixes the starting times. With lines communicating between important towns not too far apart (about 100 miles is the limit given by Major Cardew), electric traction could be introduced with advantage; in this case a frequent service of light trains would be a great benefit, especially if a number of important centres lie on the route between the termini and if there is a field for metropolitan traffic at the ends of the line. In such lines our small but densely populated country abounds.

Many additional advantages are introduced at the same time as the principal gain in the lessening of the cost of power generation. Thus the driving power can be distributed throughout the train, which results in lessening the wear of the permanent way and also in a lessening of the slip of driving wheels, as a greater proportion of the weight of the train is used for adhesion. It is easier, too, to provide power for accelerating the train and for mounting gradients, as the extra power needed in these cases is derived from an outside source, whereas if a steam engine were made powerful enough for very quick acceleration it would be too powerful for economical working during the greater portion of its running time. The concentration of power generation at a few centres leads to many economies in working expenses; coal and water are only used at the generating station, and it is only there in consequence that means for their storage and handling have to be provided.

Those who are more keenly interested in this question will do well to read the paper by Mr. Langdon to which reference has been made above. They will there find the matter thrashed out in considerable detail, both in the paper itself and in the discussion upon it, with the estimated saving worked out from a consideration of the existing traffic over a section of the Midland Railway, fifty miles long, between London and Bedford. Major Cardew discusses the problem more generally, but in his third lecture enters with some detail into the equipment of an imaginary typical full-scale railway fifty miles long; for this he arranges a suitable time schedule and then estimates the amount of power required and the approximate cost of equipment.

Major Cardew equips his imaginary railway on the polyphase system, which he considers, on account of "the advantages obtained in regard to means of conversion and from the use of higher pressure," to be most suited for use on full-scale railways. Space does not permit us to enter into a discussion of the relative merits of three-phase and direct-current working, and we must content ourselves with referring the interested reader to Major Cardew's lectures, where he will find the question fully considered. Here, in England, we are not very familiar with polyphase currents, but on the Continent, and in Switzerland especially, there are many railways thus equipped, and there can be no question of the willingness of Continental engineers to introduce their wares into this country if, as is to be feared,

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[1] "On the Supersession of the Steam by the Electric Locomotive." By W. Langdon. (*Journal* of the Institution of Electrical Engineers, vol. xxx. p. 124.)
"Electric Traction." By Major P. Cardew. Cantor Lectures. (*Journal* of the Society of Arts, July 12, 19 and 26.)

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we are incapable of supplying our own wants. Major Cardew, after considering and summing up the relative advantages of the two systems, gives his verdict against continuous current and feels "confident in prophesying the successful application of the polyphase system to the working of full-scale railways."

PRIZE-SUBJECTS IN APPLIED SCIENCE.

THE programme of subjects for which prizes will be awarded by the Société industrielle de Mulhouse next year has been issued, and copies can be obtained upon application to the secretary of the Society. In general chemistry, medals will be awarded for the best memoirs or works on the theory of the manufacture of alizarin reds; the synthesis of the colouring matters of cochineal; theoretical and practical study of the carmine of cochineal; study of the colouring matter of cotton; the composition of aniline blacks; physical and chemical modifications which occur when cotton fibre is transformed into oxycellulose; action of chlorine and its oxygen compounds upon wool; constitution of colouring matters employed in linen fabrics; synthesis of a natural colouring matter used in industries; and theory of the natural formation of an organic substance and preparation of the substance by synthesis.

In connection with dyeing, medals will be awarded for the best works presented on the following subjects:—A new mordant which admits of practical use; metallic solutions which give up their bases to textile fibres, and the conditions in which they are most effective; iron mordants and the part they play in dyeing according to their condition of oxidation and hydration; an aniline black which will not deteriorate in the presence of other colours or affect these colours, especially those of albumin; a soluble black for dyeing which will resist the action of light and soap as much as aniline black; a light blue cheap enough to be used to dye wools and not affected by boiling or by light; a blue similar to ultramarine which can be fixed upon cotton by a chemical process; a pure yellow which behaves like alizarin as regards its dyeing properties; a lake-red; a purple; a colouring matter to supersede logwood in its various applications; an assistant especially applicable to wool, capable of being cleared by simple washing, and composed of substances other than tin salts, hydrosulphites, sulphites, and bisulphites; new method of fixing aniline colours; a means of making colours resist the action of soap or of prolonged boiling; a means of producing the sheen of gold and silver upon materials by metallic powders; a manual containing tables showing the densities of as many inorganic and organic compounds as possible, in the crystallised state and in cold saturated solution; the synthesis of a substance having the essential properties of Senegal gum; a substance to supersede egg-white in the dyeing of linen; a colourless blood albumin which can be used instead of egg-white; a manual on the analysis of compounds employed in fabric printing and in dyeing; an indelible ink for marking cotton and similar materials; a practical method of removing grease spots from materials; a memoir on the use of resins in bleaching cotton fibre; a memoir on the bleaching and dyeing of various kinds of cotton; also memoirs dealing similarly with wool and silk; use of hydrogen peroxide for bleaching; improvements in the bleaching of wool and silk; and manuals on the bleaching of cotton, wool, silk, hemp and other fibres.

In connection with fabric printing, medals are offered for an alloy or other substance which has both the elasticity and durability of steel and also the property of not causing any chemical action in the presence of acid colours and colours containing certain metallic salts; a new cylinder machine capable of printing at least eight colours at once; and an application of electricity to bleaching, dyeing or fabric printing.

Among the prize subjects in mechanical arts are:—A means of recording by a graphical method the work done by steam engines in a given period (ordinary indicator diagrams do not fulfil the conditions); memoir on the spinning of combed wool; on the force required to start spinning machines; a motor for driving machines used in printing fabrics.

In electricity medals will be awarded for an electric motor the power and driving rate of which can be easily varied; a memoir on the comparative cost of electricity and gas for lighting a town having a population of at least 30,000; and comparative costs of electricity, gas, acetylene and water-gas for lighting an industrial establishment.

Money prizes as well as medals are awarded for some of the subjects, and all the competitions are open to every one, irrespective of nationality. The memoirs, designs or models submitted for the awards should be sent to the president of the Société industrielle de Mulhouse before February 15, 1902.

PROGRESS OF CIVIL ENGINEERING.[1]

IN response to a request of the Institution of Civil Engineers, Tredgold gave this ever memorable definition of civil engineering in 1828:—

"Civil engineering is the art of directing the great sources of power in Nature for the use and convenience of man; being that practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon, and changed the aspect and state of affairs in the whole world."

After a brief sketch of the objects of civil engineering, he added:—"The real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors."

A more concise and comprehensive definition of a great truth can hardly be conceived. From a physical and intellectual standpoint, a nobler aim for the exercise of the mental powers cannot be imagined than the direction of the great sources of power in Nature for the use and convenience of man. Psychology deals with mind alone, physics considers the nature and the laws of matter, but civil engineering treats of the intelligent direction of the laws governing matter so as to produce effects which will reduce to a minimum the time and physical labour required to supply all the demands of the body of man and leave more opportunity for the exercise of the mental and spiritual faculties. Philosophy, physics and civil engineering must work hand in hand. The philosopher must imagine, the physicist prove by experiment and mathematical computation, and the engineer apply to practice the laws of matter. Each must keep himself informed of the progress made by the others and must aid them by suggestions as to the lines on which research needs to be carried forward. The civil engineer, in attempting to solve some problem of construction, finds that he needs a material which shall possess a certain quality which he cannot discover that any natural product possesses. He calls the chemist to his aid, and he, from a study of the combinations of existing forms of matter which most nearly approach the desired ideal, reasons that some special combination of elements will entirely fulfil the conditions, and he experiments to find whether such combination can be made. Sometimes he is successful in his first attempt and sometimes not. But, whatever the result, he has added to his knowledge of the laws of combinations and has furnished to the philosopher fresh data for his generalisations and to the engineer a new material for his use.

As the knowledge of the nature of steel and the precise methods in which it can be manufactured have progressed, the engineer has gradually come to know just what he wants and how it can be produced, and, in his specifications, requires that the particular material of this class which he desires shall be of a certain chemical composition and also possess certain characteristics. The same is the case with almost every material which enters into the construction of engineering works of the present day. Matter in its original state is rarely used. Its chemical condition must be transformed before the engineer can utilise it with any confidence. That almost any desired transformation can be effected was not realised until late in last century. Starting with the atom, the ultimate particle of matter so far comprehended by us, the chemist found that several different kinds of atoms could be identified, and that these would combine in certain ways according to laws which could be formulated. But in the application of these laws and the tabulation of the results gaps were found to exist which could not be filled without the supposition that other elements existed than those already known. The existence of such elemental substances was confirmed by the revelations of the

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[1] Abridged from an address delivered at the annual meeting of the American Society of Civil Engineers, June 25, by the president, Mr. J. J. R. Croes.

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